



Request for Information

Program: Advanced Research Project Agency – Energy (ARPA-E)
Release Date: August 31, 2009
Deadline for Responses: September 25, 2009, 5:00PM EST
Submission Method: Responses are to be submitted as email attachments sent to arpa-e-rfi@hq.doe.gov

Objective:

The Advanced Research Projects Agency – Energy (ARPA-E) seeks public and stakeholder input on 1) programmatic areas well suited for support by ARPA-E and 2) specific scientific and technological opportunities to overcome key technological roadblocks to the development of widely market deployable transformational technologies relevant to the ARPA-E mission. The information collected through this process will assist ARPA-E in developing potential programs and funding opportunities.

Background and Rationale:

ARPA-E is a new agency of the Department of Energy modeled after the highly successful Defense Advanced Research Projects Agency (DARPA) and designed to enhance the energy and economic security of the United States. ARPA-E was authorized by the America COMPETES Act (PL 110-69) and charged with the mission to fund projects that will develop transformational technologies that reduce America's dependence on foreign energy imports; reduce U.S. energy related emissions, including greenhouse gases; improve energy efficiency across all sectors of the U.S. economy; and ensure that the United States maintains its leadership in developing and deploying advanced energy technologies. Initially funded through the American Recovery & Reinvestment Act (PL 111-5), ARPA-E aims to support the development of high risk/high payoff applied science and technology innovations that will have a positive disruptive impact on the energy landscape.

ARPA-E will not provide financial support for exploratory basic science, incremental and straightforward engineering development work, or large-scale demonstrations. Rather, ARPA-E will seek to fund transformational energy technology research and development projects involving 1) the translation of emerging scientific breakthroughs into completely new energy technologies with potentially revolutionary impact on ARPA-E mission areas and 2) the development of radical new approaches to overcome critical technical roadblocks to widespread, cost-effective deployment of emerging or existing but under-deployed energy technologies.

In addition to having strong engagement with the existing energy technology innovation community, ARPA-E is particularly interested in attracting new practitioners to the field of energy research. ARPA-E encourages responses from researchers with technical backgrounds and new technology approaches highly relevant to the ARPA-E mission areas, but who have not yet applied those skills to energy technology research.

ARPA-E will initiate funding solicitations that range from broad to narrow in scope, designed to support innovation in a broad emerging technology area of particular promise or to achieve radically improved new solutions to specific technological problems that have frustrated the development and wide-spread deployment of promising existing energy technologies. In the RFI guidelines and topics that follow, ARPA-E has outlined objectives formulated through internal planning and through informal discussions with stakeholders. ARPA-E expects to expand and revise its plans for upcoming Funding Opportunity Announcements by incorporating feedback from this RFI and conducting targeted public workshops – including stakeholders - in the near future.

RFI Guidelines:

Parties interested in responding to this RFI should first review the ARPA-E mission areas and program areas of interest described in this document, as well as the guidelines presented below in their entirety. Respondents may address multiple program areas. however, each topic should be fully addressed in a separate response.

Responses should provide a comprehensive presentation of a proposed program area, including a detailed description of the current scale of technology deployment, the current and projected state-of-the art of existing technologies related to the proposed program area in terms of technology performance and cost, the required technology performance and cost for widespread adoption, and a description of emerging opportunities for transformational technology development. Responses should be supported by industry and technical data, a discussion of key technology barriers and challenges that need to be overcome, an estimate of the scale of the resources and timeframe that will be needed to enable a revolutionary result, and justification for how the creation of an ARPA-E program in this technology area would have a strong additive impact relative to other private and public funding efforts related to this technology area. Additional questions that would be helpful to ARPA-E in response to this RFI can be found under RFI Response Instructions at the end of this document.

This is not a Funding Opportunity Announcement (FOA) and ARPA-E is not accepting new applications for financial assistance at this time. DOE will not pay for information provided through this RFI. ARPA-E is NOT seeking specific proposals with this RFI, but are interested in soliciting broader perspectives on mission related areas that would benefit from focused development activity. Responses to this notice are not offers and cannot be accepted by the Government to form a binding contract or issue a grant. Respondents are asked to focus their responses on highlighting promising areas or persistent challenges that would benefit from new approaches and why there may be new opportunities to address these challenges with potentially transformational new approaches.

Comments in response to this RFI must be provided to ARPA-E as an attachment to an email message addressed to: arpa-e-rfi@hq.doe.gov. To be considered, comments must be provided no later than 5 pm EST on September 25, 2009. All documents responding

to this RFI must be delivered electronically to the email address above using either Microsoft Word (.doc) or Adobe Acrobat (.pdf) formats and with a file size no greater than 3 MB. Power Point files (.ppt) converted to Adobe Acrobat (.pdf) files will also be accepted. Responses must be less than 10 pages or slides in length. Responses that do not meet these criteria will not be considered.

Information obtained as a result of this RFI will be used by the government for program planning on a non-attribution basis. Information with limitations or restrictions on its use is not solicited and will not be considered. **Do not include any information that might be considered proprietary and/or confidential.** There will be no specific response to submissions other than acknowledgement of their receipt. This ARPA-E RFI is seeking from the public broader non-proprietary perspectives on mission related areas that would benefit from focused research and development activity, and any resulting program activities will be developed internally by ARPA-E. Submission of responses to this RFI will not preclude a respondent's participation in future ARPA-E programs addressed by responses to this RFI.

Program Areas of Interest:

ARPA-E is not seeking to support the kinds of approaches that are already being supported through other applied DOE energy technology programs. Instead, ARPA-E will develop focused programs across a portfolio of technology sectors and is especially interested in developing programs that will provide resources to strategically accelerate the development of promising new technologies in areas that are especially amenable to transformation. Examples of such areas might include those that have historically been overlooked, areas that have experienced recent revolutionary scientific or technological advances that pave the way for transformational technology development, or areas that hold extraordinary promise for impact on ARPA-E mission areas, but that involve levels of risk too high for traditional funding agencies and mechanisms. ARPA-E believes that the challenge of clean, abundant supply and efficient use of energy will require a multi-disciplinary approach and encourages the participation of both well-established energy technology developers and new entrants to the energy technology field in addressing these challenges.

ARPA-E will consider supporting projects in all areas relevant to the ARPA-E mission. Several initial examples of high-impact areas in which ARPA-E is considering investing are listed below in order to stimulate respondent input. By no means is this to be considered an exhaustive or definitive list of ARPA-E areas of interest. ARPA-E welcomes additional ideas for further areas of interest from respondents in response to this RFI. It should be noted that in the areas listed below, ARPA-E's interest is the creation of research programs with performance and cost targets **far exceeding** the current state-of-the-art and current targets of existing DOE applied programs. The specific performance and cost levels required for new technologies to have a transformational impact on the scale and rate of technology deployment, and thus a transformational impact on ARPA-E's mission areas, will depend on the specific energy technology sector being addressed. The determination of these "transformational"

technology adoption metrics will be a critical activity in the definition of any and all ARPA-E programs. ARPA-E looks forward to respondent input to help define these transformational metrics for relevant energy technology areas.

Electrification of Transport

The development of high performance, low cost technologies to enable the shift of transportation energy to a future low-carbon power grid represents an opportunity to drastically reduce U.S. foreign oil dependence and transport related emissions.

Potential areas of interest for ARPA-E include:

- Advanced rechargeable electrical energy storage systems with dramatically lower cost and increased energy density, power density, and life-time over the current state-of-the art.
- Novel concepts and technologies for rapid charging of electrified vehicles.
- Promising materials and device designs that may lead to dramatically lower cost and higher performance power electronics.

Advanced Renewable Transportation Fuels

The development of highly efficient, low-cost methods for the conversion of solar energy to high energy density infrastructure-compatible liquid fuels will enable a shift toward a low-carbon, domestically powered transportation sector.

Potential areas of interest for ARPA-E include:

- Synthetic biological approaches to creating novel highly productive fermentative or photosynthetic organisms for the production of low cost, high energy density, infrastructure-compatible liquid and gaseous fuels.
- Thermochemical and catalytic approaches for direct conversion of biomass to low cost, high energy density, infrastructure-compatible liquid and gaseous fuels.
- Non-biological approaches for the direct production of low cost, high energy density, infrastructure-compatible liquid and gaseous fuels from solar energy.

Advanced Vehicle Technologies

The development of advanced, readily deployable technologies for drastically increasing the fuel efficiency of vehicles will enable a large reduction in fossil fuel usage in the transportation sector, dramatically decreasing U.S. foreign oil imports and energy related emissions from the transportation sector.

Potential areas of interest for ARPA-E include:

- Novel combustion engine designs and concepts that offer dramatic improvements in fuel efficiency with high reliability.
- Disruptive vehicle energy recapture technologies which offer extremely high efficiency, light-weight, and low cost.
- Revolutionary approaches to high performance, low cost lightweight vehicle materials and components.

Low Cost, Scalable, Dispatchable Centralized Renewable Power

The development of low cost, readily scalable centralized renewable power systems that can provide power on demand will dramatically reduce energy-related emissions from the

power sector and will provide low-carbon, low cost power to a future electrified transportation sector.

Potential areas of interest for ARPA-E include:

- Novel ultra-low cost, scalable, high efficiency photovoltaic materials, devices, manufacturing processes, and systems.
- Novel wind power conversion technologies capable of producing low-cost power in low-wind speed regions to enable much greater deployment of cost-effective wind power.
- Extremely robust, low cost approaches to ocean wave, tidal, and run-of-river hydropower.
- Disruptive new enabling technologies for low cost, scalable engineered geothermal power systems, including advanced drilling technologies and advanced thermodynamic cycles.
- Disruptive new approaches to concentrated solar thermal power production and thermal energy storage, including advanced optics, thermodynamic power cycles, and thermal storage materials and approaches.
- Novel scalable, low cost, easily sited grid scale energy storage technologies to enable firm power from intermittent renewable power sources.

Future Grid

The development and widespread deployment of advanced “smart grid” technologies will greatly enhance the reliability and efficiency of the U.S. electric power grid, will enable the integration of large amounts of intermittent renewable power into the grid, and will enable the efficient and harmonized utilization of all elements of the power grid.

Potential areas of interest for ARPA-E include:

- Novel advanced sensing, communications, and control technologies to enable real-time control and demand management on the grid.
- Novel advanced electrical energy storage technologies for grid stabilization, load shifting, and firm renewable power on the grid and reduction of wasteful spinning reserve requirements.
- Disruptive new approaches to advanced low loss transmission and distribution technologies.
- Novel smart infrastructure and appliances to reduce the peak load on the grid.

Distributed Energy Technologies

The development of cost effective, reliable distributed energy technologies will enable much higher energy reliability for energy consumers and provide an opportunity for consumers to reduce their energy bills by avoiding the relatively high delivered cost of electricity and natural gas.

Potential areas of interest for ARPA-E include:

- Revolutionary extremely low cost, high efficiency approaches to rooftop photovoltaics (including materials and module innovations, balance of systems innovations, and disruptive new approaches to installation).
- Disruptive new approaches to building-integrated small-scale wind power.
- Disruptive low cost building-scale technologies to capture, store, use, and convert solar thermal energy into electric power and heating/cooling services.

- Revolutionary new low cost, long lifetime building-scale electrical and thermal energy storage technologies.
- Disruptive low cost, efficient distributed cogeneration technologies, including advanced thermodynamic cycles and fuel cells.

Efficient End Use of Energy

Efficient end use of energy in buildings is considered by many to be the “lowest hanging fruit” opportunity available for decreasing energy costs to consumers and reducing energy related emissions.

Potential areas of interest for ARPA-E include:

- Novel advanced HVAC and refrigeration technologies, including highly efficient, HFC-free cooling technologies.
- Disruptive new high efficiency, low cost lighting technologies, including light emitting diodes.
- Novel advanced building envelope technologies, including low cost high R value insulation and advanced window technologies.
- Novel advanced building sensors, controls, and behavior modification technologies for high performance buildings.
- Disruptive concepts for advanced, low power electronic devices to drastically reduce energy use in data centers and other computing devices, a rapidly growing source of U.S. electric power consumption.

Low Carbon Fossil Energy Technologies

Potential areas of interest for ARPA-E include:

- Revolutionary low energy penalty, low capital cost materials and systems to enable cost-effective carbon dioxide capture, especially for post combustion coal power plant retrofit applications.
- Disruptive new advanced coal conversion technologies that provide pure carbon dioxide flue gas streams for efficient carbon capture and sequestration, including chemical looping and other advanced approaches.
- Ultra high efficiency natural gas and coal power conversion technologies.
- Disruptive novel “Negative Emissions” technologies – technologies that convert dilutestreams of carbon dioxide to stable solid forms of carbon and other technologies that permanently fix more carbon in a durable form than they release.

Energy Materials of the Future

The development of advanced new high performance materials will enable radical improvements in energy production, storage, and utilization and restore U.S. manufacturing leadership.

Potential initial areas of interest for ARPA-E include:

- Disruptive new, extremely low cost approaches to manufacturing high quality crystalline substrates and roll-to-roll manufacturing approaches for high quality crystalline substrates on low cost templates for photovoltaics, power electronics, light emitting diodes, energy harvesting and other energy conversion devices.

- Novel low cost, extremely high energy density magnetic materials for advanced motors, generators, and power transformers.
- Extremely low cost approaches to manufacturing ionic liquids for energy efficient separations, biomass conversion, coal conversion, and other energy applications.
- Revolutionary new materials approaches to ultra-high energy density rechargeable electrical energy storage.
- Novel, scalable materials and nanomaterials for energy conversion applications, including photovoltaic, LED, thermoelectrics, electrical energy storage, and other materials.
- Disruptive new extremely low cost approaches for manufacturing nanoscale materials at scale for various energy conversion applications (photovoltaics, LED's, batteries, ultracapacitors, etc.).

Industrial Efficiency

The development of advanced efficient industrial processes will decrease energy-related emissions from the U.S. industrial sector and greatly increase the global competitiveness of the U.S. industrial sector through decreased energy usage and energy related costs.

Potential areas of interest for ARPA-E include:

- Novel low cost waste heat-to-power conversion technologies, including advanced thermodynamic cycles and thermoelectric devices.
- Disruptive novel energy efficient and low carbon manufacturing approaches for energy and carbon dioxide emissions intensive industries, including forest products, chemicals, metals, cement, glass production and others; including advanced waste heat recapture techniques, novel energy efficient catalysts and processes, conversion of carbon dioxide to useful products, and integration of renewable energy sources into industrial processes.
- Disruptive novel materials and processes for energy efficient gas and liquid separations.

ARPA-E may develop programs in these and other areas, and the purpose of this RFI is to seek input from stakeholders and the public on the development of these programs.

RFI Response Instructions:

ARPA-E is interested in pursuing ideas that represent significant new approaches in the program areas of interest described above and other areas that meet the ARPA-E mission. Transformational energy research and development projects will often fall into one of two categories described in more detail below:

Category 1: Translating cutting-edge scientific discoveries into transformational new energy technologies (i.e. identification of exciting new scientific phenomena and their application to disruptive new energy technologies)

Basic scientific research often leads to the discovery of interesting new scientific phenomena or new insights and understanding into existing scientific phenomena. In some instances, there exist broad gaps in our knowledge and abilities in critical areas of

energy technology research. These gaps may be bridged by recent fundamental discoveries that have opened new avenues and opportunities for discovery and innovation in energy technology research.

Respondents are asked to describe areas of cutting edge applied science exploiting newly discovered scientific phenomena that may result in the development of new energy technologies with disruptive performance and cost profiles. In this response category, ARPA-E is seeking respondent input on cutting edge areas of applied energy science ripe for enabling fundamentally new classes of energy technologies.

In addition to a brief description of the technological area, respondents to this category should consider addressing the following questions:

- What is the new breakthrough or knowledge that can be exploited?
- How does it offer transformational impact on ARPA-E mission areas?
- How does the new approach represent a transformational departure from the current state-of-the art?
- What evidence/data exists to indicate that the new breakthrough/phenomenon holds promise to provide a transformational improvement in performance/cost over the current state-of-the-art?
- Does the new technology approach hold legitimate promise to eventually become a cost-effective, scalable new energy technology? What are some potential pathways to cost-effective scale up of the new energy technology?
- What specific enabling scientific or technological breakthroughs will be required to move the technology towards deployment?
- What are the foreseeable barriers to deployment, including non-technical barriers, and how will they be overcome?
- Are there other DOE funding programs that have previously or are currently supporting this technological area? If so, how will an ARPA-E program uniquely impact the technology area in a way that other programs would not?
- What resource level/time scale is needed for a program have high potential to translate the new breakthrough into a prototype technology indicating promise for transformational impact?

Category 2: Revolutionary approaches for overcoming critical technological barriers to enable the widespread deployment of emerging energy technologies (i.e. identification of critical areas of technology need and developing disruptive new solutions)

In many instances, the cost-effective deployment of a promising high-impact emerging energy technology is frustrated by specific well-bounded technological challenges in one or more critical “choke points” within a technology value chain. In these instances, the development of specific disruptive new technological capabilities addressing these specific critical “choke points” may enable a level of energy technology performance and cost to enable wide-spread, cost-effective deployment of an emerging energy technology. ARPA-E seeks to identify such ‘choke-points’ and to develop focused programs with well-defined performance and cost metrics that will overcome critical barriers to the wide-spread adoption of emerging energy technologies.

In this category, respondents are requested to provide input on high impact focused program areas of interest within a specific energy technology value chain that address critical technology “choke points”, details on the required performance and cost in these technology areas to enable wide-spread technology deployment, and transformational new technology approaches that have the potential to reach or exceed these technology requirements. A few examples of “choke points” include: parts of an energy technology value chain with longstanding recalcitrant technological problems; parts of the value chain with slow rates of cost reduction relative to other parts of the value chain; parts of the value chain that currently exhibit unacceptably high fundamental costs due to the use of expensive materials or non-scalable approaches; and parts of the value chain where technological improvements result in cost and performance leverage across the whole technology value chain. ARPA-E plans to develop programs designed to provide solutions to such technological barriers, and by doing so, fundamentally altering the cost-benefit characteristics of specific energy technologies.

In addition to brief descriptions of the energy technology area, critical specific technology “choke points”, and potential transformational new technologies, respondents to this category should consider addressing the following questions:

- What is the current state-of-the-art across the value chain for the energy technology of interest?
- What is the current state and scale of deployment of the energy technology?
- What is the required performance/cost of the energy technology for wide-spread deployment?
- What are the current critical “choke points” in the value chain for this energy technology? In what sense to they represent critical “choke points”?
- What are the current technology barriers and what approaches have and are currently being developed to overcome them?
- What new technologies or approaches should be explored to address these “choke points” and what is the basis for believing they will be superior to the state-of-the-art and enable wide-spread technology deployment?
- How would the successful development of these new technologies create a transformational impact on ARPA-E mission areas?
- Will the approaches enable transformational impacts across more than one energy technology area?
- What are the foreseeable barriers to deployment, including non-technical barriers, and how will they be overcome?
- Are there other DOE funding programs that have previously or are currently supporting this technological area? If so, how will an ARPA-E program uniquely impact the technology area in a way that other programs would not?
- What resource level/time scale is needed for a program have high potential to translate the new breakthrough into a prototype technology indicating promise for transformational impact?

Closing Comments

ARPA-E welcomes public input through response to this RFI and looks forward to working with the energy innovation community to 1) design highly relevant, high-impact funding programs, 2) to support the development of the next generations of transformational energy technologies and technologists, and 3) to invent and innovate our way to a low-cost, low-emissions, domestically-secure energy future for our nation. ARPA-E thanks you for considering providing your valuable input in response to this RFI.